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APPLICATION OF ECOLOGICAL, GEOLOGICAL  
AND OCEANOGRAPHIC ERTS-1 IMAGERY  
TO DELAWARE'S COASTAL RESOURCES  
PLANNING

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GEOLOGICAL AND OCEANOGRAPHIC ERTS-1  
IMAGERY TO DELAWARE'S COASTAL RESOURCES  
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## A. Problems

We had difficulty getting imagery of December 3, ERTS-1 overpass. However, this problem has been corrected since the latter part of February.

## B. Accomplishments

### a) Study of Suspended Sediment and Circulation Patterns.

Satellite imagery from four more successful ERTS-1 passes over Delaware Bay during different portions of the tidal cycle were interpreted with special emphasis on visibility of suspended sediment and its use as a natural tracer for gross circulation patterns. The images were taken on October 10 and December 3 in 1972, and on January 26, and February 13 in 1973. (NASA-ERTS-1 I. D. Nos. 1079-15133, 1133-15141, 1187-15140, and 1205-15141 respectively.) The MSS red band (band 5) appears to give the best contrast, although the sediment patterns are represented by only a few neighboring shades of grey. Color density slicing improved the differentiation of turbidity levels. However, color additive enhancements were of limited value since most of the information is in a single color band. The ability of ERTS-1 to present a synoptic view of the surface circulation over the entire bay is shown to be a valuable and unique contribution of ERTS-1 to coastal oceanography.

### b) Identification of Coastal Vegetation Species in ERTS-1 Imagery.

Coastal vegetation species appearing in the ERTS-1 images taken of Delaware Bay on August 16, and October 10, 1972 (Observation I. D. Nos. 1024-15073 and 1079-15133) have been correlated with ground truth vegetation maps, and imagery obtained from high altitude RB-57 and U-2 overflights. The vegetation maps of the entire Delaware Coast were prepared during the month of August and September, including the day of August satellite overpass, using data collected on foot, in small boats, and from low altitude aircraft. Multispectral analysis of high altitude RB-57 and U-2 photographs indicated that five vegetation communities could be clearly discriminated from 60,000 feet altitude including, 1) salt marsh cord grass (*Spartina alterniflora*), 2) salt marsh hay and spike grass (*Spartina patens* and *Distichlis spicata*), 3) reed grass (*Phragmites communis*), 4) high tide bush and sea myrtle (*Iva* species and *Baccharis halimifolia*), and 5) a group of fresh water fowl. All of these species are shown in fifteen overlay maps, covering all of Delaware's wetlands prepared to match the USGS topographic map size of 1:24,000.

Major communities of 1) *Spartina alterniflora*, 2) *Spartina patens* and *Distichlis spicata*, and 3) *Iva frutescens* and *Baccharis halimifolia* can be distinguished from each other and from surrounding uplands in ERTS-1 scanner bands #6 and #7. Similarly, major impounded areas, built to attract water fowl, can be identified. Mosquito control drainage ditches and plant species such as *Phragmites communis* which naturally occur in small, dispersed patches are impossible to discriminate within the resolution capability of the ERTS-1 scanner. In disturbed marshes of northern Delaware Bay, *Phragmites communis*, does occupy large enough expanses or marsh to be detected. In summary, it appears from preliminary analysis that spectral discrimination capabilities of ERTS-1 imagery compare favorably with those of aerial infrared photography and that spatial resolution is the dominant factor limiting the potential for detailed vegetation mapping using ERTS-1 imagery.

c) Two more papers have been presented and are being prepared for publication in journals and proceedings. (See section D of this report).

d) Ground truth has been collected during one more satellite overpass and two aircraft overflights (See Attached Tables).

### C. Significant Results

As described in Section B, communities containing five different coastal vegetation species, developed marshlands and fresh water impoundments have been identified in ERTS-1 images. Suspended sediment and circulation patterns in imagery from five ERTS-1 passes over Delaware Bay have been enhanced and correlated with predicted current patterns. The conclusions are as follows:

a) ERTS is a suitable platform for observing suspended sediment patterns and water masses synoptically over large areas.

b) Suspended sediment acts as a natural tracer allowing photo-interpreters to deduce gross current circulation patterns from ERTS-1 imagery.

c) Under atmospheric conditions encountered along the East Coast of the United States MMS band 5 seems to give the best representation of sediment load in the upper one meter of the water column. Band 4 is masked by haze-like noise, while band 6 does not penetrate sufficiently into the water column.

d) In the ERTS-1 imagery the sediment patterns are delineated by only three to four neighboring shades of grey.

e) Negative transparencies of the ERTS-1 images give better contrast whenever the suspended sediment tones fall within the first few steps of the grey scale. Considerable improvement in contrast can be obtained by more careful development of film and prints.

f) Color density slicing helps delineate the suspended sediment patterns more clearly and differentiate turbidity levels. Good results are obtained considering the small amount of time and money invested.

g) Sediment pattern enhancements obtained by additive color viewing of the four ERTS-1 MSS bands did not noticeably improve the contrast above that seen in the best band, i. e., MSS band 5. The cost and effort required to obtain these enhancements were not justified by the improvement obtained.

#### D. List of Publications

1. Szekielda, K. H., Kupferman, S. L., Klemas, V., Polis, D. F., Element Enrichment in Organic Films and Foam Associated with Aquatic Frontal Systems, Journal of Geophysical Research, Volume 77, No. 27, September 20, 1972.
2. Klemas, V., Use of Remote Sensing to Determine Natural and Man-Made Changes in the Coastal Zone, Delaware Academy of Sciences Annual Meeting, Dover, November 16, 1972.
3. Klemas, V., Srna, R., and Treasure, W., Investigation of Coastal Processes Using ERTS-1 Satellite Imagery, American Geophysical Union Annual Fall Meeting, San Francisco, California, December 4-7, 1972.
4. Klemas, V., Daiber, F., Bartlett, D., Crichton, O., Fornes, A., Application of Automated Multispectral Analysis to Delaware's Coastal Vegetation Mapping, American Society of Photogrammetry Annual Meeting, Washington, D. C., March 11-16, 1972.
5. Klemas, V., Daiber, F., Bartlett, D., Identification of Coastal Vegetation Species in ERTS-1 Imagery NASA ERTS-1 Symposium on Significant Results, Washington, D. C., March 5-9, 1973.
6. Klemas, V., Treasure, W., and Srna, R., Applicability of ERTS-1 Imagery to the Study of Suspended Sediment and Aquatic Fronts, NASA ERTS-1 Symposium on Significant Results, Washington, D.C., March 5-9, 1973.
7. Kupferman, S., Klemas, V., Polis, D., and Szekielda, K., Dynamics of Aquatic Frontal Systems in Delaware Bay, A. G. U. Meeting, Washington, D. C., April 16-20, 1973.
8. Klemas, V., Srna, R., Treasure, W., Assessment of Sediment Dispersal Patterns on Delaware Bay by use of ERTS-1 Satellite Imagery, International Symp. on Interrelationships of Estuarine and Continental Shelf Sedimentation, Bordeaux, France, July 9-14, 1973.
9. Klemas, V., Srna, R., Treasure, W., and Conrod, A., Satellite and Aircraft Studies of Suspended Matter and Aquatic Interfaces in Delaware Bay, A.S.P. Symposium on Remote Sensing in Oceanography, Orlando, Florida, October 2-5, 1973.

10. Klemas, V., Bartlett, D., Daiber, F., Mapping Delaware's Coastal Vegetation and Land Use from Aircraft and Satellites, A.S.P. Symposium on Remote Sensing in Oceanography, Orlando, Fla., October 2-5, 1973.

#### E. Conformance to Schedule

Measured from the date of ERTS-1 imagery delivery, we are on schedule.

#### F. Work Progress Evaluation

As described in Sections B, C, and D, of this report, the massive ground truth collection effort is paying off, enabling our team to interpret and correlate most of the ERTS-1 imagery of this region. Federal and State Agencies are quite impressed by our results and have offered key personnel as co-investigators.

#### G. Adequacy of Funds

Additional funding may be required to accomplish new tasks defined during the last program review.

#### H. Personnel Changes

None

#### I. Future Planned Work

1. To further correlate suspended sediment properties measured from boats with microdensitometry traces of ERTS-1 images and digital tapes.
2. To monitor and correlate with satellite imagery water temperature, salinity, dissolved oxygen, acidity, turbidity, currents and winds with ERTS data collection platforms to be installed by NASA-Wallops.
3. To extend the wetlands vegetation mapping performed using ERTS-1 to include data on the reliability to probability of success of identifying various marsh species and ecological impact signatures.
4. To study dynamic conditions at proposed off-shore sludge disposal sites by using ERTS-1 data, dye-drops, and possibility ERTS-1 data collection platforms.
5. To correlate five major pollution plumes studied from boats in the Delaware River with aircraft and ERTS-1 imagery and digital tapes.
6. Bendix Corporation will support all these efforts by analysing ERTS-1 digital tapes and preparing thematic maps based on our ground truth.
7. To publish ~~two~~ more articles in scientific journals and present ~~five~~ more papers at national and international meetings. A list of publications is shown in one of the previous sections.

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**IMAGERY FROM**  
**ERTS-1 SATELLITE OVERPASSES\***  
**OF DELAWARE BAY REGION**

<u>Date of Pass</u>	<u>Region</u>	<u>I. D. Number</u>	<u>Center Point</u> <u>Coordinates</u>	<u>Bands</u>	<u>Format</u>
8/16/72	DO	1024-15073	38.926N 73.925W	M	MSTP9
9/3/72	DO	1024-15074	38.752N 73.998W	M	MSTP
10/9/72	DB	1078-15075	38.915N 73.955W	M	MSTP9
10/10/72	DO	1079-15133	38.883N 75.346W	M	MSTP
10/27/72	DO	1096-15081	38.794N 74.016W	M	MSTP
12/2/72	DO	1132-15083	38.786 74.036W	M	MSTP
12/3/72	DB	1133-15141	38.798N 75.474W	5,6,7	MSTP9
1/26/73	DB	1187-15140	38.883N 75.346W	M	MSTP9
2/13/73	DB	1205-15141	38.960N 75.486W	M	MSTP-9

**Bands** M = 4, 5, 6, 7

Band 4 = 0.5 - 0.6 microns

Band 5 = 0.6 - 0.7 microns

Band 6 = 0.7 - 0.8 microns

Band 7 = 0.8 - 1.1 microns

**Format** M = 70 mm negative  
 S = 70 mm positive transparency  
 T = 9.5 in positive transparency  
 P = 9.5 in paper print  
 9 = 9-track tape 800 (bpi)

**Region** DB = Delaware Bay  
 DO = Delmarva Coast

\* This list shows only imagery containing less than 60% cloud cover.

ERTS AND SKYLAB AIRCRAFT OVERFLIGHTS  
OF DELAWARE BAY TEST SITE

<u>DATE</u>	<u>AIRCRAFT AND ALTITUDE</u>
September 14, 1970	RB-57 at 60,000 ft. altitude
November 4, 1971	U-2 at 65,000 ft. altitude
August 26, 1971	9 Inch Color IR at 11,500 ft.
September 15, 1972	U-2 at 65,000 ft. altitude
October 27, 1972	C-130 at 10,000 ft. altitude
December 3, 1972	U-2 at 65,000 ft. altitude
March 24, 1973	U-2 at 65,000 ft. altitude
April, 1973	C-130 at 10,000 ft.
April, 1973 - August, 1973	Sidelooking Radar Overflights
June 1, 1973	Color, red & green bands at 11,500 ft.
Summer, 1973	Laser Wave Profiling Overflights
Summer, 1973	Laser Chlorophyll and Oil Detection Overflights
Fall, 1973	RB-57 at 60,000 ft.